Evaluation of Unbonded Ultrathin Whitetopping of Brick Streets

National Concrete Pavement Technology Center

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Final Report
June 2006

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16. Abstract

Many cities in Iowa have retained the original brick street surfaces in downtown areas and in older residential areas as the base for modern driving surfaces. The original brick surfaces were not built to handle current and future traffic loadings. In recent years, these surfaces have tended to shift and become uneven, creating problems with safety. Asphaltic concrete overlays have been the typical rehabilitation technique in these situations. This has proven to be a successful rehabilitation technique in some cases; in other cases, the combination of movement of the brick and flexibility of the asphalt has proven to accentuate the original problems. Most of the existing literature on rehabilitation of brick streets shows the use of asphaltic concrete. Other rehabilitation methods include reconstruction of the brick surface and strengthening of the surface by placing asphaltic concrete or portland cement concrete, along with sand, underneath the brick layers. To date, little if anything has been done in the area of using portland cement concrete as an overlay of the brick surfaces. This final report documents the planning, construction, and performance of unbonded ultrathin whitetopping rehabilitation of a brick street in Oskaloosa, Iowa, in 2001. It also reports on a similar project in Des Moines that was constructed two years later in 2003.

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EVALUATION OF UNBONDED ULTRATHIN WHITETOPPING OF BRICK STREETS

Final Report
June 2006

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The work was completed with the cooperation of the City of Oskaloosa Public Works Director Larry Stevens and the contractor, Stevens Concrete, Ltd. This report would not have been possible without the assistance of the City of Oskaloosa engineering staff, Stevens Concrete, Ideal Ready Mix, and the Iowa Concrete Paving Association. The cooperation and professionalism of all involved in this project are appreciated. It is this type of research that makes Iowa a leader and opens the doors for portland cement concrete applications.

Special thanks also go to Bruce Braun and Steve Inman of the City of Des Moines and Brad Baumler of Concrete Technologies Inc., the contractor, for allowing the research staff to include ideas and results from the Des Moines project in this report. It helped test some ideas and consider other existing project problems and solutions that may be encountered in the construction of PCC overlays of brick streets.

INTRODUCTION

Background

Many cities in Iowa have retained the original brick street surfaces in downtown areas and in older residential areas as the base for modern driving surfaces. The original brick surfaces were not built to handle current and future traffic loadings. In recent years, these surfaces have tended to shift and become uneven, creating problems with safety. Asphaltic concrete overlays have been the typical rehabilitation technique in these situations. This has proven to be a successful rehabilitation technique in some cases; in other cases, the combination of the movement of the brick and the flexibility of the asphalt has proven to accentuate the original problems. Figures 1 and 2 show exposed brick under the asphalt and the asphalt cracked in several places.

Figure 1. Asphalt surface with exposed brick

Figure 2. Deteriorated asphaltic concrete surface

Research Objectives

The first objective of this project was to demonstrate the ability to design and place an ultrathin portland cement concrete (PCC) overlay on an existing base of asphaltic cement concrete and brick. The second objective was to evaluate the short-term (one year) and long-term (five years) performance of a portland cement concrete overlay of approximately three inches in depth, compared to that of an asphaltic cement concrete overlay of three inches in depth.

In order to accomplish the above objectives of the research, falling weight deflectometer (FWD) tests and visual distress surveys were conducted to determine the performance of the PCC overlay over time. This final report contains an evaluation of the overlay's performance at the end of five years.

PROJECT SITE DESCRIPTION

The project was constructed in the city of Oskaloosa, located in the southeastern part of central Iowa. The project itself consists of the portland cement concrete overlay of two city blocks. The curb and gutter were rebuilt to a higher elevation to allow the concrete to be placed over the brick. The project begins at Station 0 + 32, located at 8th Avenue on South D Street, and ends at Station 6 + 10, located at 6th Avenue on South D Street. See Figure 3.

In 1899, the original street was built by placing a concrete curb and gutter unit and then placing two layers of brick. The bottom layer of brick was placed in a north to south direction on its back, and the top layer was placed on edge in an east to west direction. Sand was used as filler between the bricks in both layers.

In 1960, the bricks had become deteriorated, and a three-inch lift of hot mix asphalt was placed over the bricks. Before the current construction began, near the center of the existing project, there was a utility cut that had been filled with concrete. The site also includes a 50-foot section of concrete that is a former railroad crossing. In this area, the brick had been previously removed and replaced with concrete.

The original pavement construction cross section and the overlay cross section are shown in Figure 4. This figure from the construction plans illustrates the various layers of sand, brick, and portland cement concrete overlay.

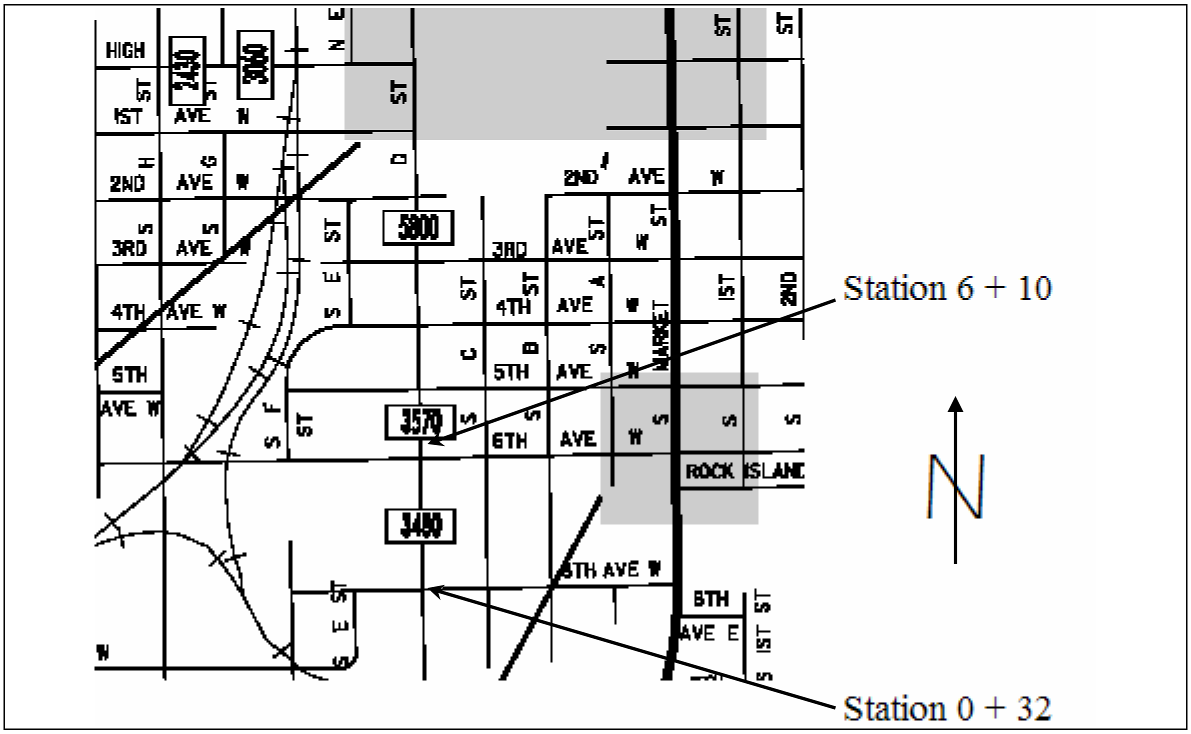

Figure 3. Project site

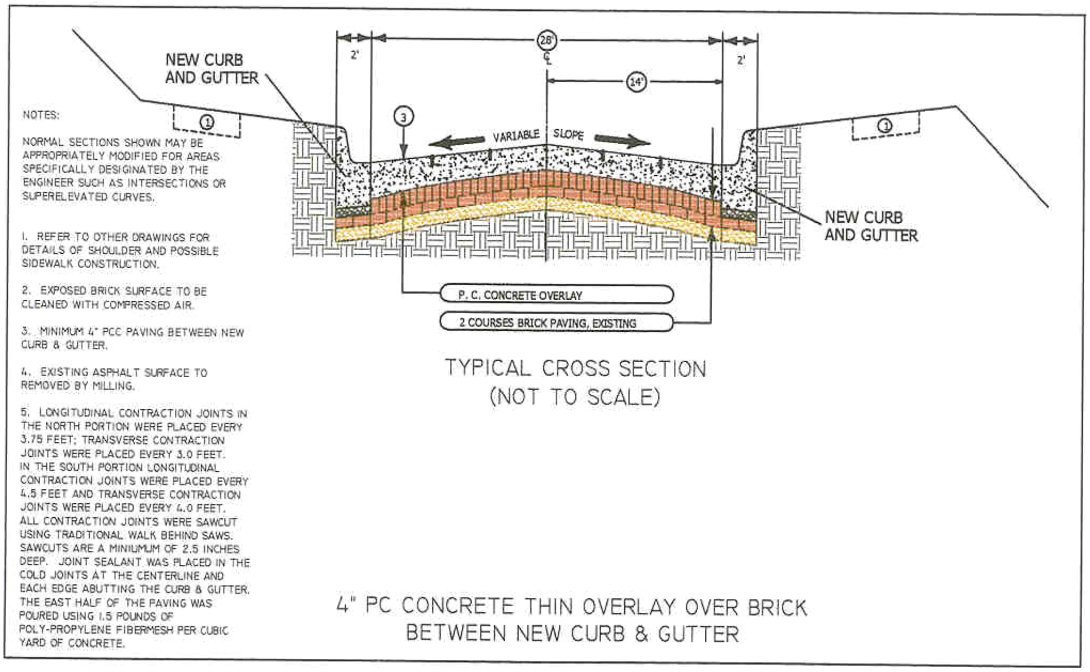

Figure 4. Design cross section

EXPERIMENTAL DESIGN

The design of this experiment included the partial removal of the existing asphaltic concrete overlay. At the same time, a full-depth removal was required at a former railroad crossing to achieve drainage. The existing curb and gutter were to be removed and replaced at an increased elevation to improve surface drainage and allow for the three- to four-inch overlay depth.

The surface area was to be subdivided into three preparation treatment areas. In one area, the overlay was to be placed on the asphalt surface; in another, the asphalt was to be pre-coated with curing compound (bond breaker); and in the third area, a film of form oil or sand was to be placed as a bond breaker.

The concrete surface was to be cut into 3.5-foot or 4.0-foot squares to a depth of T/3 and cured by normal methods.

CONSTRUCTION

The contractor first removed the existing asphalt overlay by milling and air blasting. The goal was to allow an inch of asphalt to remain on top of the brick surface, but with the weight and vibration of the milling machine, all the asphalt came loose and was removed from the bricks. The existing curb and gutter were then removed and replaced, with the contractor raising the elevation to allow for four inches of concrete to be placed on top of the existing brick, as shown in Figure 5.

Figure 5. Finished curb and gutter unit

While the contractors removed the curb and gutter, they also removed approximately an eight-inch width of brick along each edge of the street to allow a thickened edge concrete section to be placed. This area was then filled with concrete to the depth of the top layer of brick. The surface of the brick was prepared by air blasting the entire area to remove all loose materials and allow the concrete to penetrate up to one half inch down between the top layer of bricks.

The concrete slab, located in the former railroad crossing area (Station 3 + 82 to 4 + 42) was removed and replaced at full depth in order to provide proper gutter grades on the final product.

In the area south of the railroad crossing (Station 0 + 32 to 3 + 32) and in the area north of the railroad crossing (Station 4 + 42 to 6 + 10), the concrete was applied directly to the brick. The city chose to apply no debonding agents at any place in the project.

Construction of the overlay was accomplished by using a power screed. A wooden form was placed along the centerline of the roadway, and the gutter was used as a form along the outside edge. Paving was done by Steven's Concrete Ltd., and concrete was provided by Ideal Ready Mix from a nearby plant. On October 8, 2001, paving began by placing concrete in the southbound lane, going from the north and paving south through the railroad crossing. Three days later, the northbound lane was paved in the same area. On October 16, 2001, the rest of the southbound lane was paved; then two days later, the northbound lane was completed. Figure 6 shows the paving of the first lane. Figure 7 shows the first lane of paving completed.

Figure 6. Southbound lane overlay paving

Figure 7. Southbound lane paving completed

The overlay of the concrete was placed in half-roadway widths, with one or two days to be allowed between pours. A two-by-four-inch wood form was used along the centerline to establish a depth of approximately four inches. A parabolic crown was placed with the vibrating screed on each side to match the two-by-four-inch form and gutter section top elevation. No tie bars were used at centerline due to the shallow depth of the concrete overlay. The concrete specified was an Iowa DOT C-4WR mix, using a Class 3 aggregate and having a target slump of one inch. In the northbound lane, one and a half pounds of polypropylene fibers per cubic yard were added, while no fibers were added in the southbound lane.

Joints were cut with a dry saw 3/8 inches wide to a depth of T/3. The spacing of the joints from Station 0 + 32 to 3 + 82 was as follows: longitudinal joints were cut 59 inches apart and transverse joints were cut 48 inches apart. Curb and gutter sections were cut transversely at 72-inch intervals, which resulted in the curb and pavement joints matching at every third transverse pavement joint. The section from Station 3 + 82 to 4 + 42 is 10 inches in depth, with longitudinal joints every 84 inches and transverse joints occurring every 144 inches. From Station 4 + 42 to 5 + 94, longitudinal joints occur every 43 inches and transverse joints are spaced at 36-inch intervals. The section from Station 5 + 94 to 6 + 10 has longitudinal joints spaced every 43 inches and transverse joints cut at 69 inches, then 59 inches, and then another at 69 inches. In this area, brick was removed to allow for a thickened end. Figure 8 shows joints after saw cutting.

Figure 8. Completed jointing pattern

The removal of approximately one foot of brick along each edge was done to allow for a thickened edge of concrete along the curb and gutter section. This posed a problem as heavy trucks drove on the brick, causing the bricks to shift and expose the sand and dirt below. A few areas were four feet square, which were filled with concrete to a full depth. Figure 9 shows the completed project.

Figure 9. Completed project

DATA COLLECTION

Testing was conducted using the Iowa DOT FWD to accomplish deflection testing and determine the support value of the existing surface. The FWD collected information on load transfer and maximum deflection of the concrete at the joints. The existing surface was photographed in order to document the pre-overlay condition. The testing of the FWD was conducted before the street was opened to traffic and then at least once per year. The objective was to document changes in deflection over time in the surveys conducted each spring and fall. Due to equipment problems, it was not possible to get data twice per year, but at least one round of data was collected each year. The research team tried to get FWD data on the brick without any concrete placed on top. However, the data were not useful, so they were discarded. Testing locations were determined before the first test was performed and were used for each testing period over the project life.

Visual distress surveys were also conducted at the same times as the FWD testing. The testing was conducted each spring (April/May) and fall (September/October) for the duration of the contract. Additional testing was allowed for in the contract if the city noted any rapid deterioration in the condition of the PCC overlay and also prior to any maintenance rehabilitation. No such deterioration was observed over the research period.

DATA ANALYSIS

The observations of the visual distress surveys are noted below in Table 1. The table shows that there was generally good performance from the overlay. Minor defects in terms of cracking were noted near the ends of the project and in both of the smaller joint patterns. Much of this is attributed to the construction of the thickened end of the slab and the relationship of the joints in the overlay to that of the end of the brick on the bottom of the pavement. Often, the overlay thickness is difficult to control at this location and still tie the overlay into the existing pavement grade. On this project, the number of cracks noted is insignificant and cannot be tied to slab size or the presence or absence of fibers in the mix. There is no spalling or loss of material around the cracks.

Table 1. Visual distress survey observations

Date	Observation
11/30/2001:	One small transverse joint spall was noted in the north section (Northbound Lane)
5/6/2002:	No noticeable defects were detected
4/21/2003:	No noticeable defects were detected
9/18/2003:	No noticeable defects were detected
8/30/2004:	Southbound Lane, 6 panels south of north end, 2 panels left of edge, 1 corner cracked (6″ North x 6″ West)
10/4/2004:	Southbound Lane, 20 joints north of BOP, 1 transverse crack through panel at the centerline only
6/11/2005:	Southbound Lane, 5 panels south of north end, in outside row, 1 transverse crack
	Northbound Lane, 1 panel at centerline, a corner crack and diagonal at the base of the pavement
	Northbound Lane, 18 panels North of BOP, 2 panels with interior edge cracks at 1 joint right of the centerline
9/12/05:	Southbound Lane, 5 panels south of north end, in outside row, 1 transverse crack
	Northbound Lane, 1 panel at centerline, a corner crack and diagonal at the base of the pavement
	Northbound Lane, 18 panels North of BOP, 2 panels with interior edge cracks at 1 joint right of the centerline
2/25/06:	Southbound Lane, 5 panels south of north end, in outside row, 1 transverse crack
Final survey	Northbound Lane, 1 panel at centerline, a corner crack and diagonal at the base of the pavement
	Northbound Lane, 18 panels North of BOP, 2 panels with interior edge cracks at 1 joint right of the centerline

Some 6 locations in the Southbound lane and 7 locations in the Northbound lane were selected for FWD testing. The average percent of joint load transfer between sensors 3 and 4 is summarized below in Table 2 for each test period, slab size, and direction. All FWD raw data is provided in the Appendix A.

Table 2. Summary of average load transfer

Date	Panel Width	Northbound (%)	Southbound (%)
12/6/2001	43″ x 36″	84.75	85.17
	59″ x 48″	90.03	93.37
	84″ x 144″	90.78	79.14
5/6/2002	43″ x 36″	81.49	80.69
	59″ x 48″	85.71	88.71
	84″ x 144″	88.55	88.34
9/30/2002	43″ x 36″	89.74	88.09
	59″ x 48″	90.91	91.76
	84″ x 144″	95.46	91.91
11/3/2003	43″ x 36″	69.57	72.36
	59″ x 48″	66.91	80.18
	84″ x 144″	37.68	39.75
4/14/2004	43″ x 36″	70.18	85.21
	59″ x 48″	84.98	91.41
	84″ x 144″	70.48	92.29
4/27/2005	43″ x 36″	75.53	85.35
	59″ x 48″	90.93	90.94
	84″ x 144″	92.69	91.58
10/4/2005	43″ x 36″	86.05	83.76
	59″ x 48″	90.83	92.58
	84″ x 144″	94.85	91.09

Note: All FWD deflection values represent field values normalized to a 70ºF pavement temperature.

The deflection (FWD) data indicated good load transfer in all test locations, slab sizes, and testing periods. Adequate load transfer is maintained when the test values are 70% or higher. In this case, that value is maintained in all sections. Higher values are noted for the larger slabs on this project. This is partially due to the mass of the concrete in the 84″ x 144″ slabs (full depth), as compared to the overlay smaller slabs. The research team is satisfied with the range of values for each of the sections, test dates, and lanes over the testing period and terms this project a success.

DES MOINES, EAST 18TH STREET OVERLAY

In the summer of 2003, the Des Moines Public Works Department decided to develop a project similar to the Oskaloosa overlay. Two blocks of East 18th Street were selected for the project. The route serves as a heavy truck connection between a portion of I-235 and grain-processing facilities to the south of the test area.

The existing pavement consisted of an asphalt overlay (4–6 inches in depth) of a single layer of brick standing on edge. The brick was supported by a 4–6-inch layer of sandy gravel (3/4-inch diameter maximum size). The surface of the asphalt surface was rutted and, in places, portland cement or asphaltic concrete patches had been placed over utility repairs. Asphalt shoving was occurring at each end of the project where the vehicles were required to stop. The pavement edges were contained with a 6-inch-high bull-curb that turned out not to present a true grade line for the paving. This route also contains several manhole and water valve appurtances in the traveled way. The width of the existing pavement was 25 feet from back-back of curb. All the asphalt was removed prior to the addition of the new overlay. The brick surface was air blasted to remove loose materials. Figures 10 through 15 illustrate the surface preparation process that was used prior to concrete placement.

Figure 10. Existing pavement and bull-curb

Figure 11. Milled surface and existing PCC patches

Figure 12. Replacement curb and gutter units in place

Figure 13. Air blasted surface

Figure 14. Water valve adjustment area

Figure 15. Manhole box out preparation

The specifications for this project were patterned after the Oskaloosa project and represent the next step in the evolution of standard specifications for this type of work. A copy of the specifications can be found in Appendix B.

The project was constructed in September of 2003 with the use of readymix concrete delivery to a hand-operated power screed, as shown in Figures 16 and 17. The concrete placement proceeded smoothly from the south end to the north end. Special hand work was required at the north end on the second day due to the widened connection to an existing concrete pavement. Manholes and water valves were boxed out and the concrete was placed after the main pavement placement. The contractor was unable to achieve a good profile using the top of the existing curbs. The ICPA staff suggested that a 2-foot-wide gutter unit be placed on each side prior to the main paving. These units and the addition of a power screed with a built-in parabolic crown served to shape the concrete overlay to the required cross section and depth. With the existence of a 2-foot curb and gutter unit on each side of the pavement, the remaining 20 feet were cut into four equally spaced joints of approximately 4-foot squares. The change allowed for the gutter pavement surfaces to serve as the mainline pavement edge profiles. The change in joint spacing removed the longitudinal joints from the wheelpaths. An Iowa DOT standard C-4WR mix with 2.5 pounds of poly fibers added was used for the mix.

Figure 16. Initial concrete overlay placement

Figure 17. Concrete delivery method

Two cores were taken at random locations on October 2, 2003, to review the bond between the two pavement materials. Perfect bond was found, as shown in Figure 18. A nominal three inches of concrete were placed over the existing brick.

Figure 18. PCC over brick core

The project was reviewed for pavement distress immediately after opening to traffic and again on June 11, 2005. No distress was noted in the first survey. In the second survey, a minor amount of distress was noted in the following places:

- Northbound lane—minor corner breaks in 3–5 panels throughout the project in the outer wheel path.
- Southbound lane—one fractured slab in the outer wheel path at the northeast corner of the park. It could well be a location where the concrete depth was lowered to assure drainage into an existing inlet.
- Transition section at the north end of the project—four fractured larger slabs and two diagonally cracked slabs. One longitudinal joint has opened. It would appear that the construction techniques and the jointing pattern needed improvement at this location.

The project development and construction went very well and the pavement overlay is performing well for the type of traffic that it is serving. A photo of the finished project, taken later in the fall after construction, is shown in Figure 19.

Figure 19. Finished project

CONCLUSIONS

The Oskaloosa and Des Moines projects have proved that the PCC overlay of brick streets is feasible and performs well under heavy truck route conditions. It can be placed very quickly with minimal closure and traffic delay. Conventional mixes with the addition of poly fibers can be used to insure performance from the 3–4.5-inch deep overlay sections.

RECOMMENDATIONS

PCC has proven to be a viable option for overlaying existing brick streets. In areas where asphalt overlays have failed in the past due to the overlay material's flexibility, an ultrathin PCC overlay will be a better alternative.

Design and construction guidelines include the following steps:

1. Identify the amount and type of traffic to utilize this pavement in the design period. Design periods of any length can be designed. It is important to estimate the type and amount of truck traffic.
2. Core the existing pavement to determine the amount of existing overlay materials to remove, the condition and orientation of the brick, and the depth, classification, and condition of the base materials.
3. Determine the condition of the existing curb/gutter and how it will be incorporated into the new pavement or replaced and used for pavement grade control. If the curb and gutter are to be replaced, do it prior to removal of the

asphalt overlay. It may be possible to use the existing gutter pavement or a replacement to establish the grade line of the pavement overlay. Minimize the disturbance to the brick if removal and replacement is to take place.

4. Determine the joint spacing, longitudinal and transverse, to be used in the overlay. Retain the pavement gutter joint and a centerline joint, and divide the existing pavement into equally sized units, approximately square in nature. Try to extend transverse joints in the pavement to match those in the curb and gutter where possible. The maximum spacing for transverse and longitudinal joints in feet should not exceed twice the overlay depth in inches for normal concrete mixes. Larger spacing can be considered where certain types of fibers are considered for inclusion in the mix. Do not place longitudinal joints in the wheel paths if at all possible.
5. For overlay depths greater than 3.5 inches, the addition of fibers is optional. For depth of less than 3.5 inches, construction depth control is very important and the inclusion of fibers increases the reliability of the performance. Depths of 3.5 inches or greater are advised due to the construction control needed.
6. Remove all existing asphalt from the top of the bricks and air blast the brick surface clean. Remove in such a manner that trucks (empty or full) do not drive on the brick. Once the brick is exposed, minimize the construction traffic on it to reduce shoving of the brick.
7. Place the concrete in one continuous, full-width operation, if possible, to reduce the amount of heavy vehicles directly on the bricks. If single-lane construction is planned, allow for adequate strength gain in the concrete to allow for trucks before placing the second side. If single-lane construction is used, do not allow any traffic on the remaining brick during the strength gain period on the first side. It is advisable to reduce concrete loads to 6 cubic yards, if possible, to aid in the protection of the existing brick during placement. Place a deeper section (6–8 inches) transition between the overlay and existing pavement to contain the overlay and make the transition in jointing and depth.
8. Payment for the concrete should be done in both cubic yard and square yard to reduce risk to the contractor and fill irregularities in the brick surface.
9. Texture and apply the curing materials immediately behind the finishing operation. This is a thin section and must be protected at all times during curing. Establish the joints as soon as the pavement allows for early entry sawing to a depth of T/3 or 1.5 inches. Joint sealing is optional.
10. Use the maturity concept to monitor strength gain in the pavement and allow for early opening to traffic, public, or construction vehicles.

APPENDIX A: FWD RAW DATA

FWD Data: 12/6/2001

Station	Test No.	North	South	Temp., °F	Applied Load, k	d(1), mm	d(2), mm	d(3), mm	d(4), mm	d(5), mm	d(6), mm	d(7), mm	d(8), mm	d(9), mm	Load Transfer (%)
0.000	2	X		54.6	8.73	12.64	12.09	11.54	10.58	9.53	7.23	5.22	3.74	11.51	91.67
0.000	4	X		57.9	8.82	18.90	18.59	17.70	15.41	13.01	8.74	5.66	4.72	15.68	87.09
0.000	6	X		56.8	8.75	13.89	13.47	12.66	11.56	10.51	8.59	6.86	5.02	11.33	91.33
0.000	8	X		57.9	8.74	9.03	9.27	9.18	8.33	7.25	5.46	4.15	3.32	7.66	90.78
0.000	10	X		52.0	9.06	23.44	23.03	22.27	18.90	15.41	9.64	5.28	3.65	18.98	84.89
0.000	12	X		55.7	8.87	18.59	17.29	16.32	13.81	11.84	8.90	6.64	4.89	15.61	84.60
0.000	2		X	57.9	8.16	23.28	22.66	21.37	18.20	14.92	9.51	5.69	3.86	17.45	85.12
0.000	4		X	58.6	8.59	17.83	16.13	14.86	12.66	10.62	7.11	4.52	3.28	15.39	85.21
0.000	6		X	59.7	9.03	9.74	9.79	9.78	7.74	6.89	5.38	4.12	3.32	8.36	79.14
0.000	8		X	58.2	9.06	9.98	10.10	10.07	9.81	9.54	8.08	6.27	4.47	9.41	97.49
0.000	10		X	57.9	8.47	15.92	15.75	15.29	13.64	11.53	8.14	5.73	4.07	12.90	89.17
0.000	12		X	59.3	8.55	10.48	10.29	10.08	9.42	8.63	6.72	4.86	3.69	9.55	93.44

Note: All FWD deflection values represent field values normalized to a 70ºF pavement temperature.

FWD Data: 5/6/2002

Station	Test No.	North	South	Temp., °F	Applied Load, k	d(1), mm	d(2), mm	d(3), mm	d(4), mm	d(5), mm	d(6), mm	d(7), mm	d(8), mm	d(9), mm	Load Transfer (%)
40.000	2	X		64.1	9.31	13.14	12.18	11.44	10.46	9.48	7.47	5.63	4.19	11.74	91.41
148.000	4	X		64.8	8.95	24.64	23.34	20.57	16.99	13.72	8.35	4.57	3.34	17.20	82.62
299.000	6	X		67.0	8.14	30.66	30.58	27.15	22.60	18.71	12.27	8.15	6.08	23.14	83.22
416.000	8	X		66.7	9.27	10.69	10.37	9.62	8.52	7.57	5.75	4.37	3.51	9.01	88.55
498.000	10	X		66.3	8.67	21.42	20.69	18.12	14.90	12.00	7.25	4.44	3.81	15.92	82.23
601.000	12	X		67.4	8.92	19.16	18.61	16.08	12.98	10.09	5.43	3.38	3.06	14.81	80.75
601.000	2		X	67.4	8.59	25.03	24.13	20.79	16.42	12.83	7.20	4.31	3.42	18.12	78.97
502.000	4		X	69.2	9.02	16.99	16.99	14.95	12.32	10.14	6.62	4.42	3.09	14.04	82.41
400.000	6		X	68.8	9.22	9.27	9.03	8.29	7.33	6.38	4.90	3.72	2.79	7.78	88.34
290.000	8		X	68.8	9.35	11.57	11.39	10.83	10.02	9.14	7.40	5.74	4.34	10.22	92.58
141.000	10		X	69.2	8.59	15.73	15.62	13.94	11.87	10.09	7.19	5.07	1.87	12.08	85.12
39.000	12		X	69.6	8.63	11.27	11.24	10.34	9.14	7.96	5.96	4.30	2.93	9.24	88.42

Note: All FWD deflection values represent field values normalized to a 70ºF pavement temperature.

FWD Data: 9/30/02

Station	Test No.	North	South	Temp., °F	Applied Load, k	d(1), mm	d(2), mm	d(3), mm	d(4), mm	d(5), mm	d(6), mm	d(7), mm	d(8), mm	d(9), mm	Load Transfer (%)
0.000	2		X	86.1	8.59	17.51	16.00	15.15	13.17	10.80	7.00	4.31	3.18	14.78	86.91
0.000	4		X	85.7	8.72	13.48	12.56	12.09	10.79	9.03	6.04	3.76	2.31	11.44	89.26
0.000	6		X	87.5	8.89	6.09	6.03	6.03	5.54	4.94	3.80	2.92	2.36	5.32	91.91
0.000	8		X	88.3	8.54	9.24	9.04	8.97	8.17	7.12	5.30	3.88	2.91	7.90	91.16
0.000	10		X	87.9	8.42	11.55	11.16	11.00	9.91	8.44	5.99	4.12	2.81	9.56	90.15
0.000	12		X	87.2	8,25	8.32	8.52	8.91	8.37	7.40	5.59	4.07	2.81	7.02	93.96
0.000	2	X		82.8	8.70	8.22	7.52	7.45	6.90	6.27	4.92	3.67	2.49	7.81	92.62
0.000	4	X		86.4	8.83	13.08	13.19	13.34	11.97	9.90	6.54	4.30	3.20	12.17	89.74
0.000	6	X		87.9	9.45	11.83	11.35	11.22	10.13	8.55	5.92	4.05	2.80	9.87	90.28
0.000	8	X		89.0	9.47	12.47	11.89	11.89	10.82	9.59	7.52	5.82	4.38	10.95	91.01
0.000	10	X		92.3	8.98	6.96	7.00	7.19	6.86	6.11	4.72	3.57	2.61	6.03	95.46
0.000	12	X		90.5	9.25	13.65	13.47	13.38	11.90	9.93	6.69	4.18	3.14	11.49	88.96
0.000	14	X		87.2	8.98	13.09	13.04	13.04	11.81	10.02	6.96	4.57	3.24	11.16	90.52

Note: All FWD deflection values represent field values normalized to a 70ºF pavement temperature.

FWD Data: 11/3/2003

Station	Test No.	North	South	Temp., °F	Applied Load, k	d(1), mm	d(2), mm	d(3), mm	d(4), mm	d(5), mm	d(6), mm	d(7), mm	d(8), mm	d(9), mm	Load Transfer (%)
40.000	2	X		50.2	9.14	14.82	13.74	13.01	12.05	10.93	8.78	6.57	4.74	15.02	92.60
147.000	4	X		50.5	8.70	23.47	26.23	24.19	16.98	13.97	8.90	5.23	3.55	17.26	70.20
292.000	6	X		50.2	8.67	22.24	23.33	23.65	17.88	15.00	10.05	6.27	3.97	18.07	75.59
359.000	8	X		50.5	8.54	26.28	29.23	30.62	8.95	8.28	6.85	5.50	4.34	20.61	29.24
401.000	10	X		50.5	9.01	15.64	17.45	18.39	6.93	4.98	5.23	4.30	3.59	12.79	37.68
496.000	12	X		50.2	8.69	23.18	24.32	24.58	12.66	10.81	7.63	5.24	3.54	18.81	51.50
597.000	14	X		49.8	8.22	28.70	29.57	29.69	26.02	21.53	13.31	7.06	5.76	24.98	87.64
597.000	2		X	51.6	8.59	35.41	34.31	31.50	23.96	19.60	12.21	6.16	4.54	29.86	76.06
499.000	4		X	50.2	8.48	23.62	24.22	24.11	16.55	13.75	8.99	5.24	3.54	19.23	68.65
400.000	6		X	51.6	9.00	15.03	16.33	18.46	7.34	6.57	5.13	3.97	3.49	12.59	39.75
292.000	8		X	51.3	8.74	20.39	21.91	22.50	17.37	15.00	10.38	6.75	4.98	16.48	77.20
150.000	10		X	51.6	8.81	26.30	22.55	22.17	19.98	16.81	11.18	6.72	4.98	18.34	90.15
41.000	12		X	51.3	9.02	14.63	15.90	16.44	12.04	10.59	8.08	5.88	3.66	12.28	73.20

Note: All FWD deflection values represent field values normalized to a 70ºF pavement temperature.

FWD Data: 4/14/2004

Station	Test No.	North	South	Temp., °F	Applied Load, k	d(1), mm	d(2), mm	d(3), mm	d(4), mm	d(5), mm	d(6), mm	d(7), mm	d(8), mm	d(9), mm	Load Transfer (%)
41.000	2	X		63.0	8.58	10.30	9.52	8.96	8.17	7.29	5.50	3.69	2.40	10.42	91.19
152.000	4	X		64.1	8.22	16.83	18.16	18.38	13.13	11.07	7.50	4.79	3.49	12.82	71.42
295.000	6	X		69.6	8.48	16.27	16.68	16.47	14.63	12.23	8.07	4.84	3.27	13.41	88.83
364.000	8	X		69.2	8.61	16.11	16.34	16.17	12.02	10.68	8.47	6.45	4.83	13.91	74.30
418.000	10	X		72.1	8.48	8.57	9.21	9.50	6.70	5.87	4.39	3.17	2.51	7.18	70.48
498.000	12	X		69.9	8.57	17.52	17.20	16.76	14.85	12.11	7.38	3.58	2.81	15.22	88.59
603.000	14	X		67.4	8.47	21.83	22.10	21.97	11.37	9.61	6.17	3.80	3.24	18.66	51.77
495.000	2		X	72.9	8.44	17.87	17.47	17.15	14.87	12.25	7.61	3.97	2.69	15.06	86.73
394.000	4		X	72.1	9.57	9.14	9.15	9.28	7.77	6.87	5.27	3.89	3.16	8.13	83.68
281.000	6		X	74.0	9.23	15.40	15.30	15.33	14.15	12.30	8.87	6.04	4.27	13.33	92.29
146.000	8		X	74.0	9.36	15.49	15.08	14.90	13.46	11.35	7.78	5.03	3.41	12.71	90.35
41.000	10		X	72.5	9.44	9.99	10.21	10.50	9.70	8.66	6.68	4.90	3.48	8.71	92.46

Note: All FWD deflection values represent field values normalized to a 70°F pavement temperature.

FWD Data: 4/29/2005

Station	Test No.	North	South	Temp., °F	Applied Load, k	d(1), mm	d(2), mm	d(3), mm	d(4), mm	d(5), mm	d(6), mm	d(7), mm	d(8), mm	d(9), mm	Load Transfer (%)
40.000	2	X		74.0	8.99	10.79	10.46	9.92	9.10	8.24	6.60	4.86	3.35	10.32	91.71
148.000	4	X		76.2	8.92	14.35	14.74	14.20	12.82	10.73	7.31	4.67	3.50	11.72	90.30
286.000	6	X		77.3	9.24	14.03	14.26	13.71	12.59	10.56	7.25	4.63	3.17	11.69	91.81
354.000	8	X		75.4	9.22	11.54	11.40	10.82	9.73	8.53	6.70	5.03	3.69	10.18	89.88
397.000	10	X		78.0	9.46	7.23	7.57	7.49	6.95	6.16	4.83	3.62	2.71	6.37	92.69
500.000	12	X		75.8	8.94	14.23	14.02	13.25	11.66	9.70	6.55	3.89	3.13	11.89	88.01
603.000	14	X		76.2	9.07	16.78	17.10	16.55	10.44	8.89	6.27	3.96	3.33	14.42	63.04
603.000	2		X	74.3	8.52	22.83	20.59	18.64	15.58	12.62	8.04	4.57	2.52	15.16	83.58
501.000	4		X	75.8	8.95	15.07	14.89	14.05	12.24	10.09	6.88	4.28	3.26	12.28	87.11
394.000	6		X	75.4	9.46	7.02	7.06	6.83	6.26	5.56	4.46	3.38	2.94	6.34	91.58
294.000	8		X	75.1	9.04	12.20	12.43	12.05	10.99	9.54	7.21	5.10	3.62	10.46	91.18
148.000	10		X	75.1	9.21	13.15	12.96	12.30	10.87	9.17	6.59	4.52	3.13	11.14	88.33
45.000	12		X	72.1	9.29	8.97	9.17	8.98	8.38	7.50	6.01	4.54	3.34	8.14	93.30

Note: All FWD deflection values represent field values normalized to a 70°F pavement temperature.

FWD Data: 10/4/2005

Station	Test No.	North	South	Temp., °F	Applied Load, k	d(1), mm	d(2), mm	d(3), mm	d(4), mm	d(5), mm	d(6), mm	d(7), mm	d(8), mm	d(9), mm	Load Transfer (%)
41.000	2	X		84.2	8.34	8.16	7.64	7.34	6.87	6.11	4.94	3.67	2.84	7.97	93.54
147.000	4	X		89.4	8.28	10.84	10.39	9.87	8.89	7.82	5.57	3.77	2.90	9.23	90.08
287.000	6	X		90.5	8.25	10.94	10.70	10.38	9.33	7.81	5.46	3.59	2.81	9.22	89.87
354.000	8	X		92.3	8.62	10.19	9.76	9.44	8.48	7.33	5.69	4.20	3.09	9.21	89.80
397.000	10	X		93.8	8.46	5.74	5.99	6.08	5.77	5.01	3.84	2.87	2.22	4.97	94.85
4933.000	12	X		90.5	8.03	11.25	11.08	10.75	9.54	7.76	5.07	3.02	2.38	9.40	88.71
588.000	14	X		84.6	8.07	13.29	13.71	13.75	11.47	9.55	6.40	3.59	2.79	11.47	83.39
2002.000	2		X	92.3	8.07	19.26	18.38	17.46	14.42	11.75	7.49	3.94	2.44	16.75	82.58
2097.000	4		X	92.3	8.00	12.95	12.40	11.88	10.09	8.21	5.38	3.31	2.38	10.77	84.94
2191.000	6		X	94.5	8.62	5.99	6.06	6.07	5.53	4.84	3.81	2.92	2.44	5.33	91.09
2300.000	8		X	94.1	8.31	9.95	10.19	10.03	9.26	8.03	6.06	4.20	3.25	9.05	92.36
2435.000	10		X	94.1	8.51	11.88	11.60	11.24	10.15	8.62	6.24	4.15	3.01	10.15	90.34
2537.000	12		X	94.5	8.65	7.21	7.38	7.48	7.11	7.48	7.11	6.29	2.54	6.39	95.05

Note: All FWD deflection values represent field values normalized to a 70ºF pavement temperature.

APPENDIX B: CONSTRUCTION SPECIFICATIONS

ENGINEERING DEPARTMENT
CITY OF DES MOINES, IOWA

SPECIAL PROVISION FOR 2003 PORTLAND CEMENT CONCRETE OVERLAY PROJECT

East 18th Street from Dean Avenue to Walnut Street

ACTIVITY ID

1. GENERAL REQUIREMENTS

1.1 Scope of Work

The work shall consist of placing a Portland Cement Concrete (PCC) overlay on an existing composite pavement of brick that has been previously overlaid with hot mix asphalt (HMA). The existing HMA surface will be removed prior to placement of the PCC overlay.

Placement by means of slip form equipment, forms/vibrating screed, or bridge-deck finisher shall be required with profile reference to top of existing curb sections as directed by the engineer.

This contract will be a City-contractor cooperative effort with specified responsibilities for each party.

Unless otherwise specified, all work shall conform to the Urban Standard Specifications for Construction of Public Improvements, 1998 Edition, and all subsequent revisions.

1.1.1 City Responsibilities

The City Public Works Department shall be responsible for the project management, including scheduling, notification of affected property owners and the public; traffic control, including traffic control devices, placement and maintenance of traffic control devices, and removal of traffic control devices; removal of the existing HMA surface; and opening completed street to traffic.

1.1.2 Contractor Responsibilities

The contractor shall be responsible for furnishing the specified C-4 Portland Cement Concrete (PCC) mix with fibrillated polypropylene fibers; surface preparation; placement of a 3" minimum PCC overlay on an existing composite pavement of brick, by means of slip form equipment, forms/vibrating screed, or bridge-deck finisher; curing, including necessary materials; sawing required joints; sealing of joints; and clean-up, removal and disposal of excess concrete, including concrete behind and on the forms, providing protection from the weather from the time he arrives on the site until the street is open to traffic and providing quality control management as specified by these specifications. Contractor shall provide all labor, materials and equipment and perform all work necessary to accomplish the above-stated responsibilities.

The contractor shall purchase and maintain insurance to protect the contractor and City against all hazards as specified by the standard specifications.

1.2 Plans

There are no drawn plans for this work other than standard details to which reference is given by these specifications.

1.3 Construction Schedule

The PCC overlay shall be completed in 15 working days from the start of the project.

1.4 Traffic Control

The City shall furnish all traffic control, including all traffic control devices and personnel required for the placement, maintenance, and removal of the traffic control. The contractor shall coordinate with the Public Works Department to ensure that all required traffic control is in place prior to work.

1.5 Contract Quantities

It is understood that the quantities are estimated for the purpose of this bid. All quantities are subject to revision by the City. <u>Quantity changes, which amount to twenty (20) percent or less of the total bid for an item shall not affect the unit bid price</u>.

1.6 Measurement for Payment

Portland Cement Concrete Overlay, Furnish Only – Payment for the quantity of concrete furnished, measured in cubic yards and using a count of batches supplied, shall be in accordance with 7010, 1.08 P (Portland Cement Concrete Resurfacing) of the Urban Standards and Specifications for Public Improvements Manual. This quantity will include concrete placed in partial and full depth patches.

Portland Cement Concrete Overlay, Placement Only – Payment for the quantity of concrete placed, measured in square yards, will be in accordance with 7010, 1.08 P (Portland Cement Concrete Resurfacing) of the Urban Standards and Specifications for Public Improvements Manual, and will be the quantity shown in the contract documents. This payment shall be full compensation for furnishing all labor, equipment, tools, supplies, mobilization and incidental related items necessary to complete the work.

2. EQUIPMENT

Equipment shall be subject to approval of the jurisdictional engineer and shall comply with Section 7010, 2.07 D of the Urban Standard Specifications for Construction of Public Improvements, 1998 Edition, and all subsequent revisions, with the addition of bridge-deck finishing equipment.

3. MATERIALS

Materials, including Portland cement concrete, curing compound and joint seal material, shall conform to Section 7040 of the Urban Standard Specifications for Construction of Public Improvements, 1998 Edition, and all subsequent revisions. The contractor shall incorporate graded fibrillated polypropylene fibers in the specified C-4 Portland cement concrete mix in accordance with the fiber manufacturer’s directions. The fibers shall be added to the mix at a dosage rate of 2 ½ pounds of fiber per cubic yard of concrete. The fibers shall be mixed into the fresh concrete so they are uniformly distributed throughout each batch of concrete and there is no clumping of fibers.

4. SURFACE PREPARATION

Following removal of the existing HMA surface, the City will broom the street to remove latent material. The contractor shall clean the street surface immediately prior to paving by air blasting.

5. DEBONDING

Immediately prior to paving, the faces of the existing curbs shall be sprayed with two coats of white pigmented liquid curing compound as defined in Section 2.02 M.4.

6. PLACEMENT

Placement of the Portland cement concrete (PCC) shall conform to Section 7040-3.04 of the Urban Standard Specifications for Construction of Public Improvements, 1998 Edition, and all subsequent revisions. The PCC shall be placed at a 3" minimum thickness except at the 8' long transitional areas located at both ends of the project. The transitional areas shall consist of a 4'long segment of 9" thickness PCC adjacent to the existing pavements at Dean Avenue and Walnut Street, followed by a 4'segment of 6" thickness PCC transitioning to the 3" PCC overlay.

7. CURING

Curing of the Portland cement concrete shall conform to Section 7040-3.04 of the Urban Standard Specifications for Construction of Public Improvements, 1998 Edition, and all subsequent revisions.

8. SAWING AND SEALING OF JOINTS

Sawing and sealing of joints shall conform to Section 7040-3.04 of the Urban Standard Specifications for Construction of Public Improvements, 1998 Edition, and all subsequent revisions.

Contraction Joints – Joints shall be sawed to a width of 1/8" with early entry/"green" cutting concrete saws as soon as the concrete is capable of supporting the sawing operation. These joints shall not be sealed. Longitudinal and transverse contraction joints shall be saw cut at 4' intervals both ways.

Construction Joints – Construction joints at curb face only shall be tooled with concrete edging hand tool while concrete is in its plastic state or sawed to create reservoir for joint sealant. All construction joints shall be cleaned with air blasting in accordance with Section 7010, 3.10 B.2. These joints shall be sealed without backer rod and in accordance with Section 7010, 3.10 B.4.

9. RE-OPENING OF STREET

The Contractor shall use the maturity method to determine the time for opening the pavement to traffic.

10. QUALITY CONTROL

The contractor shall provide quality control management, provide testing, and maintain the quality characteristics to meet all levels of tolerances and specifications.